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ENVIRONMENTAL RESEARCH

RESEARCH AND TECHNOLOGY BRANCH

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for

ENVIRONMENTAL RESEARCH AND TECHNOLOGY

1992

STRATEGIC DIRECTIONS

for

ENVIRONMENTAL RESEARCH AND TECHNOLOGY

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TABLE OF CONTENTS

(i) Introduction.....1

(ii) List of Research Coordinators.....7

(iii) Areas of Research:

(A) Acid Rain.....8
(B) Air Quality.....11
(C) Analytical Instrumentation.....18
(D) Biotechnology.....21
(E) Environmental Socio-Economics.....24
(F) Multimedia Contaminants.....28
(G) Pest Control.....36
(H) 3 Rs.....43
(I) Waste Management.....48
(J) Water Management (including Sewage Treatment).....51

INTRODUCTION

The Research and Technology Branch (RTB) is concerned with maximizing the benefits resulting from the environmental research and technology development funded by the Ministry of the Environment (MOE). Our responsibility is to support work that will best serve the priority programs of the ministry, work that will smooth the way to successful program implementation by facilitating the solution of those problems which impede their delivery.

In order to properly discharge its mandate, RTB embarked on an initiative aimed at establishing the strategic directions for research at MOE. The purpose of the exercise was to identify:

(a) the priority programs of the Ministry; and
(b) the specific research/technology questions in each program.

The resulting product is **Strategic Directions for Research and Technology - 1992**. It is not a final product because research needs will constantly evolve, as priorities change and as research problems change form or are solved. This document is intended to provide greater precision to the definition of research needs, and thus better guidance to the applicant in the formulation of proposals. The document is one part of an enhanced research and technology management process which will link all activities to a Ministry plan, and ensure that funded projects contribute in a measurable way to the achievement of MOE objectives.

Updates to this document will be issued as often as required to keep the information current.

KEY MINISTRY THRUSTS AND PRIORITY PROGRAMS:

"Key ministry thrusts" are the principles upon which current programs are interpreted and developing programs will be based. **Priority programs** are the ones that are currently deemed most essential for advancing "key ministry thrusts".

A short paper entitled "Three Key Thrusts of the Ministry of the Environment - 1991/92" follows this Introduction. It provides the context for a reorientation of the research and technology program as reflected in the restructuring of this document.

AREAS / TOPICS:

Despite an increasing multi-media approach to the environment, proposals are classified into Research and Technology **areas** in order to enable appropriate scientific and technical review. Each of the ten areas has a Coordinator (see the following section). The areas of research & technology are:

A. ACID RAIN

B. AIR QUALITY

C. ANALYTICAL INSTRUMENTATION

D. BIOTECHNOLOGY

E. ENVIRONMENTAL SOCIO-ECONOMICS

F. MULTI-MEDIA CONTAMINANTS

G. PEST CONTROL

H. 3Rs

I. WASTE MANAGEMENT

J. WATER MANAGEMENT (including Sewage Treatment)

Pest Control research has been integrated into the Research & Technology program in 1992; it was previously a separate program under The Ontario Pesticides Advisory Committee (OPAC).

The research and technology **"Topic"** is the specific question to be addressed. **The Topic towards which a proposal is directed should be referenced in the application**. Each topic is numbered using the alphabetic character for the area (as in the list above), followed by a numeric for the issue being adddressed, and a second sequential numeric for the topic. Example: Topic J-3.1.

All of the topics described in this volume are related to the Ministry programs in the Table on Page 3. Some explanations: H-(1,2,3,4,5,6,7,8,9,10,11,12,13,14) indicates all of the topics listed under issues H-1 through H-14. I-7.(1,2) indicates topics I-7.1 and I-7.2.

SUMMARY OF RESEARCH & TECHNOLOGY TOPICS

MINISTRY PROGRAMS	APPLICABLE ISSUES AND TOPICS
ACCELERATED 3Rs*	H-(1,2,3,4,5,6,7,8,9,10,11,12,13,14); I-7.(1,2)
AIR TOXICS/ GLOBAL WARMING	A-2.(1,2,3); A-3.1; A-5.(1,2,3); B-1.(1,2,3); B-4.(1,2,3); B-6.1; B-7.(1,2,3); B-8.(1,2); F-(1,2,3,4); I-4.(1,2,3); I-6.2; I-7.3; I-8.(1,2)
BEACHES RESTORATION	J-1.(1,2,3,4)
BIOTECHNOLOGY	D-1.(1,2,3,4); D-2.(1,2); D-3.(1,2,3)
COUNTDOWN ACID RAIN	A-1.(1,2,3); A-4.(1,2,3)
DRINKING WATER PROTECTION	F-1.(1,2); F-3.1; D-1.(1,3); J-4.(1,2,3,4,5,6,7,8)
GROUNDWATER PROTECTION	I-(1,2); I-3.1; I-5.(1,2,3); I-6.(1,2); J-5.(1,2,3)
LONG RANGE TRANSPORT	A-3.(1,2,3); B-1.(1,2,3); B-4.(1,2,3); B-14.(1,2,3)
MATERIALS MANAGEMENT POLICY	F-3.4; I-8.(1,2,3)
MISA PROGRAM	F-1.(1,2); D-3.2; J-3.(1,2,3,4,5,6,7,8)
MULTIMEDIA	B-2.(1,2,3); B-8.3; F-(1,2,3,4)
OZONE DEPLETION	B-13.(1,2)
PESTICIDE REDUCTION	G-(1,2,3,4,5,6,7)
REMEDIAL ACTION PLANS	D-3.(1,2,3); J-6.(1,2,3,4)
RISK ASSESSMENT	B-5.(1,2,3); B-10.(1,2,3,4); E-2.(1,2,3); F-(1,2,3,4); D-1.(1,2); H-9.(1,2); H-12.3; J-7.1
VEHICLE EMISSIONS STRATEGY	B-6.3; B-11.(1,2,3); B-12.(1,2,3)
MULTI-PROGRAM SUPPORT	B-3.(1,2,3); B-6.2; B-9.(1,2,3); C-(1,2,3,4,5); E-1.(1,2,3); E-(3,4,5,6,7,8); I-1.(1,3); I-2.(1,2,3); I-3.(2,3); I-5.(1,2,3); I-6.3; I-7.3; I-8.3; J-2.(1,2); J-8.(1,2,3,4,5)

* see "Initiatives Paper No. 1: Regulatory Measures to Achieve Ontario's Waste Reduction Targets", released for public consultation by the Ministry of the Environment, October 1991. Available from the Research and Technology Branch (416) 323-4649.

PROGRAMS FUNDED BY THE RESEARCH AND TECHNOLOGY BRANCH:

The R&T funding programs of the Research and Technology Branch are the **Environmental Research Program** (ERP) and the **Environmental Technologies Program** (ETP).

ERP provides research grants and contracts for university and private consultants for well-developed, technically sound research projects addressing one of the topics identified in this volume.

ETP funds technology development, up to the level of full-scale field trials, and technical demonstrations. Also, environmental technologies developed elsewhere may be tested for suitability to Ontario conditions. ETP is a partnership program covering up to 50% of the costs of research and development.

Proponents should indicate on the application form the number of the topic being addressed. *Proposals which are not related to a specific topic may also qualify for financial assistance.* Full program descriptions including eligibility criteria are included in Funding Application kits obtainable from the **Grants Assistant** at (416) 323-4649. Specific questions on these programs can be addressed to the **Environmental Research Analyst** at (416) 323-4575 and the **Environmental Technologies Analyst** at (416) 323-4627.

1992 DEADLINES FOR SUBMISSIONS:

Environmental Research Program (ERP) - JANUARY 15, 1992

Environmental Technologies Program (ETP) - APRIL 30, 1992; OCTOBER 30, 1992

Three Key Thrusts of the Ministry of the Environment - 1991/92

Pollution Prevention:

Traditionally, technology driven pollution control has been the primary instrument used to protect the environment. Pollution control has primarily relied upon end-of-pipe and top-of-stack technologies to reduce contaminant loadings to the environment.

Pollution remediation has been the second major instrument used for environmental protection. Recent examples of pollution remediation are the clean-up of the St. Clair River Blob, the destruction of PCB waste at Smithville, the removal of lead contaminated soil from Toronto area communities. A common feature of these remediation activities has been the astronomical cost associated with them. Undoing pollution damage after the fact is prohibitively expensive.

The third instrument, and the one that has been least used, is pollution prevention. There are five key elements to pollution prevention:

- reduction at source
- substitution
- process change
- product redesign
- behaviour change

Adoption of pollution prevention as a key instrument for environmental protection requires us to get away from reliance on end-of-pipe technology. It will necessitate the introduction of closed loop systems within plants to prevent the discharge of contaminants to the environment; it will require substitution of raw materials to avoid the generation of harmful by-products or wastes; it will require the introduction of process changes and product redesign to minimize the amount and degree of hazard to the waste stream. Last, but not least, it will require a major behaviour change in our attitudes to the environment.

Zero Discharge:

Toxic substances which are carcinogenic, mutagenic, teratogenic, bioaccumulative, persistent should not in any circumstance be discharged into or be present in the environment. The goal of Ontario's Municipal Industrial Strategy for Abatement (MISA) is the virtual elimination of persistent toxics. Zero discharge is one of the methods by which this goal can be achieved. Few argue the goal. The debate centres on how virtual elimination will be achieved, how success will be measured, how long it will take and how much it will cost.

Multi-media Approach:

This is the approach that will be taken in respect of the design and implementation of all ministry environmental protection programs.

The multi-media approach implies that when a plant is being assessed for environmental performance, its discharges to air, water and land will be integrated into the assessment.

The approach would eliminate those processes which facilitate the cross-transfer and release of contaminants to other environmental media. Standard setting would take into account all the pathways of a contaminant to a specific receptor.

LIST OF RESEARCH COORDINATORS

Proponents are welcome to contact the ERP/ETP Coordinators to discuss the feasibility of proposed projects and to obtain further insight into the research problems of interest to the Ministry. Coordinators are listed below as well as the Managers for the ERP and ETP.

(A).	Acid Rain	Dr. Neville Reid	326-1691
(B).	Air Quality	Dr. Neville Reid	326-1691
(C).	Analytical Instrumentation	Dr. Ray Clement	235-5900
(D).	Biotechnology	Dr. Roland Weiler	323-5103
(E).	Environmental Socio-Economics	Mr. Nilam Bedi	323-4626
(F).	Multimedia Contaminants	Dr. Roland Weiler	323-5103
(G).	Pest Control	Mr. Doug Mewett	323-4551
(H).	3 Rs	Mr. Ron Neilson	325-4419
(I).	Waste Management	Mr. Mel Fielding	323-5146
(J).	Water Management	Mr. John Ralston	323-4924
Manager, Environmental Research Program		Mr. Joel Kurtz	323-4484
Manager, Environmental Technologies Program		Mr. Doug Vallery	323-4476

(A) ACID RAIN

Issue A-1: ***Countdown Acid Rain***

Topics:

A-1.1 Does the current wet sulphate critical load of 20 kg/ha/yr adequately protect Ontario's aquatic resources and what is an appropriate nitrogen critical load for aquatic ecosystems?

A-1.2 Will the implementation of the Countdown and U.S. Clean Air Act amendments result in significant recovery of Ontario lakes and streams? If so, what recovery rate can be expected?

A-1.3 Is the current critical load for sulphur adequate to protect terrestrial resources (forestry, agriculture, soils) and should a nitrogen critical load be established?

Issue A-2: ***Global Warming Strategy***

Topics:

A-2.1 Confirmation of the regional environmental effects (aquatic, terrestrial, atmospheric) and socio-economic implications of global warming in Ontario based on current scientific predictions of climate change.

A-2.2 Development of adaptation strategies to offset the predicted regional effects.

A-2.3 Development of limitation measures/strategies to reduce the emissions of greenhouse gases in Ontario.

Issue A-3: ***Long Range Transport of Air Toxics Pollutants (LRTAP)***

Topics:

A-3.1 Refinement of budgets and cycling of selected air toxics for Ontario.

A-3.2 What are the sources of and sensitive receptors to LRTAP?

A-3.3 What is the chemical and biological impact (nature and extent) of LRTAP on Ontario's environment?

Issue A-4: ***Post-Countdown Strategy***

Topics:

A-4.1 Should there be further SO_2 emission reductions beyond 1994 to protect aquatic resources and comply with federal-provincial, and international agreements?

A-4.2 Which sources are the most cost-effective to regulate?

A-4.3 Development of technologies to facilitate the reduction of SO_2 and NO_x emissions.

Issue A-5: ***NO_x / VOCs Management***

Topics:

A-5.1 What levels of NO_x / VOCs emission reductions can be achieved through motor vehicle inspection and/or maintenance and retrofit technologies for source control?

A-5.2 Refinement of models to estimate benefits in Ontario of ground level ozone reduction.

A-5.3 Development of technologies, control options and costs which will contribute to NO_x/VOCs management in Ontario.

(B) AIR QUALITY

Issue B-1: ***Tropospheric Ozone***

Topics:

B-1.1 What are the relative importance of NO_x, anthropogenic VOCs and biogenic VOCs in the formation of ozone?

B-1.2 What is the most cost effective manner to control ozone in urban and rural settings (are there differences between the two) and what are the benefits and drawbacks of these controls?

B-1.3 What are the effects on health and vegetation of ozone and what are the dose metrics that lead to these effects?

Issue B-2: ***Air/Soil/Water Interactions***

Topics:

B-2.1 Which multimedia pathways are the most significant from an exposure point of view, and what are appropriate ways (eg. both in terms of short-term 'bridging' assumptions and long-term experimental validation of pathway transfers) of reducing the uncertainties in these and other pathways to allow for credible pathway assessments?

B-2.2 What are the approaches (ie. both long-term 'equilibrium' and short-term 'non-equilibrium' type approaches) for assessing the appropriateness of a chemical specific standard for its potential to contaminate other media through air/soil/water interactions?

B-2.3 What are the biodegradation rates of organic contaminants in soil and their availability to plants under natural field conditions?

Issue B-3: ***Atmospheric Chemistry***

Topics:

B-3.1 What are the mechanisms and rates of the atmospheric reactions of important semi-volatile organic compounds (PAHs, PCBs, organo-chlorine pesticides, etc.) and the hydrocarbons participating in ozone formation (especially isoprene, terpenes and aromatics)?

B-3.2 What is the role of hydrated aerosols in the attachment and chemical reaction of gaseous species?

B-3.3 How do grid size and atmospheric turbulence affect chemical profiles, dispersion and chemical reaction rates in models?

Issue B-4: ***Global Warming***

Topics:

B-4.1 What are the strengths of the sources and sinks of natural and anthropogenic greenhouse gases in Ontario, and their roles in global warming?

B-4.2 What are the implications of global warming on current air environmental issues in Ontario, such as NO_x/VOCs/O_3, acid rain, toxics, etc.?

B-4.3 What are the effects of unseasonable temperature fluctuations on crop and forest growth and can temperature trend models be produced from the back-development of old growth forest data to determine climate change over time?

Issue B-5: ***Personal Exposure***

Topics:

B-5.1 Can any of the current and historical province-wide ambient contaminant network results be used for personal risk/total exposure studies?

B-5.2 From a personal risk exposure perspective, what is the rank of specific air pollutants?

B-5.3 Is it better to characterize the major microenvironments in which people work and live or is it better to characterize the total exposures for different groups of people?

Issue B-6: ***Volatile organics***

Topics:

B-6.1 Can network-type, semi-real-time monitoring instruments, and/or improved sampling and analytical methods be developed for VOCs?

B-6.2 Are there significant gaps in our knowledge of the physical properties (such as vapour pressure, solubility, and the Henry's Law constant) of important atmospheric pollutants that must be addressed to improve estimates of wet scavenging, dry deposition, air/water exchange and volatilisation from surfaces?

B-6.3 Can improved emission rate estimates, including speciation, be made for specific source sectors, including surface coating processes, commercial solvent use, combustion sources, and crop, forest and contaminated soil emissions?

Issue B-7: ***Semi-volatiles***

Topics:

B-7.1 How can atmospheric samples best be analysed for halogenated and nitrated PAHs, and brominated dioxins and furans? Can real-time or pseudo real-time sampling methods be developed for PAHs and derivatives?

B-7.2 What is the distribution of semivolatile organic chemicals between the gas and particle phases, both at the point of emission and as the plume travels downwind? Can surrogates be used to characterize total semi-volatile emissions?

B-7.3 What are the important reactions by which PAHs decay/transform causing air sampling artifacts? How can these effects best be circumvented?

Issue B-8: ***Metals***

Topics:

B-8.1 Can routine, network monitoring methods be developed for mercury, and arsenic in air and precipitation? Can real-time monitoring instruments for mercury in air be improved?

B-8.2 What are the particle size distributions for various metals as emitted and at receptor sites?

B-8.3 How phytotoxic are metals (and VOCs and semi-volatiles) in contaminated soils and how are they deposited and bioaccumulated in terrestrial biota?

Issue B-9: ***Odours***

Topics:

B-9.1 Do current analytical techniques address odour problems?

B-9.2 Can real-time methods be developed which will respond to brief (a few minute) odour problems?

B-9.3 Can methods be developed to quantify the subjective nature of odours?

Issue B-10: ***Standards***

Topics:

B-10.1 What are appropriate ways of bridging the gap between the 'single chemical/ single standard' approach and the reality of human and environmental exposure to multiple chemicals in the following areas:

- assessment of ambient air quality?
- assessment of the impact of a single source or facility?
- assessment of the impact of multiple sources?

B-10.2 What approaches are appropriate for defining averaging times for an ambient air standard and what are appropriate ways of extrapolating among various averaging periods?

B-10.3 In the continuum of 'total suspended particulate matter (TSP), inhalable particulate matter (IP), specific chemical' standards, what are the most appropriate combinations of monitoring, and standard development in order to ensure proper protection of air quality and human health?

B-10.4 Can point of impingement standards be applied to personal risk assessment applications?

Issue B-11: ***Alternative Fuels***

Topics:

B-11.1 Do we have a toxic (or other) air pollution problem that can be solved through the use of alternative fuels. What are the adverse effects (health and otherwise) associated with each of the proposed alternative fuels.

B-11.2 What is the best industrial process for producing ethanol from Ontario renewable resources (from the viewpoint of net CO_2 production/reduction, energy efficiency, etc.)?

B-11.3 Can a computer model be developed which will evaluate and demonstrate the optimum use of alternative fuels?

Issue B-12: ***Vehicle Emissions***

Topics:

B-12.1 What are the transient vehicle emissions related to cold starts, acceleration and idling? Can a reasonable test procedure be developed for the "in-use" determination and control of NO_x, CO and hydrocarbons (especially PAHs) under these conditions?

B-12.2 What are the tightest "in-use" tailpipe emission standards for CO and HC that could be considered realistic?

B-12.3 What is the availability, accumulation and phytotoxicity of inorganic and organic species of Mn present in automobile car exhausts? What other toxic species are emitted by motor vehicles?

Issue B-13: ***Stratospheric Ozone***

Topics:

B-13.1 What is the role of anthropogenic emissions in Ontario that lead to stratospheric ozone depletion and what are the health implications?

B-13.2 What are the effects of increased U.V. radiation on crop and forest productivity?

Issue B-14: ***Acid Aerosols***

Topics:

B-14.1 How can acid aerosols be monitored on a routine basis in the province?

B-14.2 What are the spatial and temporal characteristics of acid aerosol concentrations in Ontario? What is the contribution of local and distant sources to acid aerosols in Ontario?

B-14.3 What is the threshold for exposure to acid aerosols? Is there a single threshold value? What is the importance of synergism between acids, trace metals (such as Mg, Mn), sulphur dioxide, and ozone? Do acids act merely as promoters for chronic and acute effects?

(C) ANALYTICAL INSTRUMENTATION

Issue C-1: *Environmental Real-Matrix Certified Reference Materials (CRMs) for Organic and Inorganic Analytes*

Topics:

C-1.1 How do we manufacture (economically) CRMs for a variety of environmental sample types including water, soil, air, sludge, fish, etc.?

C-1.2 How do we make and certify reference standards for hydrophobic organic analytes (dioxins, furans, PCBs, PAHs, etc.)?

C-1.3 What are the certified analyte concentrations and what is the stability during long-term storage of any CRMs produced?

Issue C-2: *Automation of Analysis Methods for Organic Analytes*

Topics:

C-2.1 How can methods such as SPE, SFE, HPLC, thermal stripping, or any other novel technique be used to automate sample extraction and concentration?

C-2.2 How methods be integrated to perform fully automated analysis from start to finish?

C-2.3 How can the efficiency of chromatographic separations be increased to allow a greater number of analytes to be determined in a single analysis?

Issue C-3: *Automation of Analysis Methods for Inorganic Analytes*

Topics:

C-3.1 How do we speed-up the acid digestion step?

C-3.2 How do we reduce the number of chemicals used for and the cost of acid digestion?

C-3.3 How do we make acid digestion more complete for samples like sediments?

C-3.4 How do we avoid loss of volatile analytes?

Issue C-4: ***Multiple Analyte Determinations***

Topics:

C-4.1 Can existing methods be modified or replaced by new ones that are capable of determining ever-increasing numbers of analytes in a single sample?

C-4.2 How can single samples be split, fractionated, treated, or handled to allow multiple analyte determination without sacrificing detection limits, precision, or accuracy?

Issue C-5: ***Specific Analytical Methods***

Topics:

C-5.1 Nitrilotriacetic acid in water and soil by using GC/MS at detection limits better than 25 ppb.

C-5.2 Glyphosate in water.

(D) BIOTECHNOLOGY

Biotechnology has been defined as the application of living organisms or their products to provide goods and services. It is necessary to regulate the potential impacts associated with the production and use of biotechnology products.

The Ministry has identified the following priority research requirements to support regulation development:

- risk assessment of novel organisms prior to their introduction into the environment
- bioremediation to degrade toxic compounds *in situ*
- biological alternatives to chemical pest control agents
- strategies for public information and education about biotechnology.

Issue D-1:

Development of scientific methodology designed to support the risk assessment criteria needed for assessing the potential environmental impacts of novel, genetically engineered organisms.

Topics:

D-1.1 Development of predictive models for assessing transport, survival, and activity of microorganisms and/or novel genetic material released in a subsurface environment.

D-1.2 Evaluation of the long term environmental impact posed by the introduction and commercialization of different classes of herbicide tolerant crops in Ontario.

D-1.3 Development and evaluation of sensitive methods for detecting and accurately enumerating populations of microorganisms in terrestrial and aquatic environments.

D-1.4 Development of genetic or biochemical markers which can be used to unambiguously identify and quantify populations of novel organisms introduced into the environment.

Issue D-2:

Development of methods to increase the general level of awareness of both the benefits and the risks of biotechnology.

Topics:

D-2.1 Evaluation and assessment of public attitudes and perceptions toward environmental applications of biotechnology including genetically altered organisms.

D-2.2 Development of strategies to increase public awareness and understanding of the issues surrounding biotechnology, especially as they relate to environmental applications of this technology.

Issue D-3:

Exploration of the applications of biotechnology which can reduce our dependence on chemical control agents or which provide an alternate means of degrading chemical contaminants.

Topics:

D-3.1 Investigation and examination of the metabolic pathways involved in the microbial degradation of recalcitrant chemical contaminants.

D-3.2 Development of methods to evaluate the microbial ecology and degradative potential of microbial populations at contaminated sites and in biologically based waste treatment systems. Particular emphasis could be placed on developing methods for sites contaminated with chlorinated aromatic compounds.

D-3.3 Development of methods to monitor and validate *in situ* bioremediation processes.

(E) ENVIRONMENTAL SOCIO-ECONOMICS

Issue E-1: ***Environmental Benefits and Damages***

Topics:

E-1.1 Adapt, develop and apply human health and risk dose-response relationship functions for toxic-hazardous compounds to predict and quantify damages from specific pollutants, economic activities or development projects, taking into account both short-term and long-term consequences.

E-1.2 Adapt, develop and apply human health and risk dose-response relationships for toxic substances to predict and quantify the beneficial consequences that result from abatement and pollution prevention activities.

E-1.3 Document the private benefits (eg. recovered by-products, cost reductions, raw material and energy savings, product quality improvements, etc.) of industrial abatement technologies, systems or programs and the implications of such benefits on investment and growth.

Issue E-2: ***Risk Assessment***

Topics:

E-2.1 Adapt, develop and apply methods to determine the relative importance people place on different types of risk (including voluntary risks and both short and long-term risks) and how much people value reductions in such risks.

E-2.2 Adapt, develop and apply methods to produce inventories of various resources at risk.

E-2.3 Develop and assess approaches for the communication of risk to the public.

Issue E-3: ***Economic Instruments***

Topics:

E-3.1 Design and test economic incentive policy instruments for the attainment of environmental objectives.

Issue E-4: ***Social Impacts***

Topics:

E-4.1 Development of a better understanding of the factors that can explain and determine varying social and psychological attitudes, perceptions and environmental behaviour.

E-4.2 Development and evaluation of social monitoring methods.

Issue E-5: ***Market Assessment***

Topics:

E-5.1 Evaluate, using economic theory, tools and techniques, secondary materials markets in Ontario.

E-5.2 The role and effectiveness of "green consumerism".

Issue E-6: ***Information Gathering***

Topics:

E-6.1 Compile statistics required for socio-economic analyses. For example, industrial (ICI) waste generation by SIC, environmental expenditures, information on green industries (including the Environmental Protection industry), and state of the environment statistics.

E-6.2 Compile indicators of environmental-economy linkages, such as alternate measures to GNP.

Issue E-7: ***Social Costs and Benefits***

Topics:

E-7.1 Develop and apply standard methods for identifying and quantifying social costs.

E-7.2 Development of environmental preference and environmental quality of life indices.

Issue E-8: ***Environmental Accounting***

Topics:

E-8.1 Methods to value environmental resources.

E-8.2 Develop and apply standard methods for identifying and quantifying to social and economic costs of environmental resource use.

(F) MULTIMEDIA CONTAMINANTS

MULTI-MEDIA APPROACH:

Direction has been given to incorporate multi-media approaches into all Ministry programs. The multi-media approach considers:

- release to and presence of a contaminant in several environmental compartments;
- the relative exposure of a receptor to a contaminant through different pathways;
- the differential toxicity and level of risk for a receptor posed by combined exposures.

RISK ASSESSMENT:

The public continues to expect that the contaminants present in the environment do not pose an unacceptable risk to human health or the ecosystem. Risk assessment is a tool for answering these concerns. It involves the evaluation of risk from a chemical based on the dose-response relationships for all possible toxic endpoints for all receptors, including humans, and the consideration of the exposure potential for the receptors. Risk assessment is the first step in setting of standards, which is the development of specific environmental or human health criteria based on the risk assessment of the chemical and the attendant legal, socioeconomic, regulatory and technical issues. Public consultation is an important part of the process.

PESTICIDE REDUCTION:

Research is required for developing new initiatives for reducing the use of pesticides in the urban environment.

Issue F-1:

Development of methods for identifying chemicals that are hazardous. This involves the identification of previously unassessed chemicals in all environmental media and the preliminary assessment of the potential hazard of these chemicals to selected biota, including humans.

Topics:

F-1.1 Development of models linking structure-activity relationships to the toxicity and the environmental fate of new chemicals.

F-1.2 Information on the environmental fate of multimedia chemicals and on concentrations of such chemicals in the environment.

Issue F-2:

Development of methods for assessing the risk to humans of hazardous multimedia chemicals.

Topic:

F-2.1 Development of the methodology for risk assessment of mixtures of related compounds and of the data necessary to use the methods. Priority is given for mixtures of PAHs.

Issue F-3:

Development of methods and guidelines for multimedia exposure assessment and for reducing the uncertainties in the estimation of multimedia exposures. This includes both total and target organ exposures:

Topics:

F-3.1 Development of biochemical, genetic and immunological techniques as indicators of human and target organ to hazardous chemicals. These methods require validation and comparison with other exposure assessments. The major chemicals of interest are dioxins and dibenzofurans, PAHs, PCBs, nitrosamines and lead.

F-3.2 Development of new information and models for extrapolating animal exposure data from experiments to equivalent human exposures. An example is the evaluation of PAH-DNA adducts.

F-3.3 Development and validation of pharmacokinetic models of delivered doses of chemicals or metabolites to target organs to allow for more biologically based assessments of exposure.

F-3.4 Measurement of the bioavailability of chemicals on ingested or inhaled particulates, in ingested soil and food.

F-3.5 Development and validation of exposure models to estimate source, fate, concentrations and interactions of receptors with chemicals.

Issue F-4:

Studies of the adverse effects of chemicals on human health. The adverse effects include cancer and non-cancer endpoints such as neurotoxicity and reproductive and developmental effects.

F-4.1 Develop criteria for evaluation of neuromuscular and psychomotor development.

F-4.2 Investigations into the effect of exposure (dosing) schedule on the toxicity of carcinogenic and neurotoxic chemicals or developmental and reproductive toxins. For example, models relating the dose regime to length of time when tumours appear.

F-4.3 Studies on the effects of nutritional deficiencies on the toxicity of ingested inorganic arsenic in humans.

F-4.4 Validation of genotoxicity tests deemed to be suitable for use in developing standards or in regulatory decisions prior to their use as a predictive tool. The MOE policy on the funding of Genotoxicity Research is provided on pages 32-34. The criteria for validation are listed on page 35.

The following policy was recently implemented in order to focus research funding in this area.

GENOTOXICITY POLICY

DEFINITIONS

Genotoxicity: A measure of an agent's ability to alter the integrity of the genome. An agent which is genotoxic is not necessarily mutagenic.

Mutagenicity: A measure of an agent's ability to cause a heritable change (mutation) in genetic material in either somatic or germ cells. An agent which is mutagenic is always genotoxic.

Validation: A positive, statistically significant, correlation between results seen in short term predictive test systems (e.g. genotoxicity tests) and either long term test systems or epidemiological study results. A test which has been validated will therefore have a quantitative measure of confidence with respect to its predictive capabilities.

BACKGROUND

During the last decade the Ministry of the Environment has funded the development and use of a large number of genotoxicity tests. As the resources available for funding these developments decrease, it is becoming more important that the Ministry follow a more focused approach to genotoxicity research funding to ensure that maximum benefits are realized. To this end, the Research Advisory Committee commissioned the preparation of a document entitled "Review of Established Regulatory Policies using Genotoxicity Tests, Current Capabilities, and Recommendations for Future Development". The goal of this review was to provide RAC with a summary of information pertaining to the use of genotoxicity testing by other government agencies, the current status of genotoxicity test use within the Ministry, and the likely future role of such testing so that a policy outlining genotoxicity research priorities could be developed.

The present document represents the consensus of the RAC Genotoxicity Sub-committee based on review of the consultant's report and input from MOE Branches currently using genotoxicity tests and test results.

STATE OF THE SCIENCE AND REGULATORY USE

There is considerable scientific uncertainty about the significance of positive genotoxicity tests. As a result of this uncertainty, most agencies do not use genotoxicity test results as the sole basis for direct regulatory action. In general, regulatory agencies are using the results from genotoxicity tests as supporting information together with other toxicological information for regulatory decisions. Genotoxicity tests currently in use have not yet been fully validated in that information on end-points and dose-response relationships has not been correlated with end-points and genotoxicity dose-response relationships derived from long term studies. At present, in order to establish the strength of the association between these tests, there is a need to place a greater emphasis on the validation of genotoxicity tests as predictive tools for determining an agent's potential to cause adverse health effects such as cancer, genetic disease, detrimental reproductive effects, etc..

FOCUS OF FUTURE RESEARCH

Current Ministry research efforts should focus on the scientific validation of tests which are currently in use or recommended for use for risk assessment, standards development and environmental monitoring. Specifically:

- Current research efforts should be focused on the validation of tests which quantitatively measure the impact on organisms exposed to environmental levels of genotoxic pollutants. To be multi-media in scope, such tests should be available to assess the atmospheric and terrestrial as well as the aquatic environments.

- Research efforts should be initiated to scientifically validate the use of genotoxicity in risk assessment and standard setting. This research would include examination of the limits, strengths and weaknesses associated with the qualitative and quantitative use of genotoxicity data in such assessments.

Table 1 lists the tests that are currently in use, or have been recommended for use, by the Ministry. Possible Validation Criteria is included as a guide to proponents.

While emphasizing the validation of currently existing genotoxicity tests, the Ministry does not wish to preclude the development of new genotoxicity tests. Funding to develop additional test protocols will be contingent upon:

(a) Failure of efforts to validate existing test protocols; and/or,

(b) Evidence that the proposed test will be significantly superior to test protocols already in use.

Newly developed test systems will also be required to be validated prior to their acceptance for use.

OPPORTUNITIES FOR PARTNERSHIPS

The Ministry recognizes the mutual advantages inherent in the development of research partnerships with external agencies to work towards a common goal. Therefore, preference will be given to those research proposals designed to be collaborative projects with other external agencies.

TABLE 1: Genotoxicity tests which are currently in use, or recommended for use, by the Ministry of the Environment.

TEST SYSTEM		
IN VITRO	*IN VIVO*	*IN SITU*
Salmonella/mammalian microsomal assay	Micronucleus assay	Plant assays: i) Micronucleus assay in *Tradescantia paludosa*; ii) Stamen hair assay in *T. paludosa*
Escherichia coli point mutation assay	Chromosomal aberration assay	Fish assays: i) Cytogenetic analysis; ii) Tumour induction; iii) Other assays
Micronucleus assay	Sister chromatid exchange assay (SCE)	Amphibian assays: i) Micronucleus test; ii) Germ line lethal tests; iii) SCE
Point mutation assay	Unscheduled DNA synthesis assay	
Sister chromatid exchange assay (SCE)	Specific locus assay in mouse	
Unscheduled DNA synthesis assay	Spot test in mouse	
	Dominant lethal test	
	Heritable translocation assay	

POSSIBLE VALIDATION CRITERIA

(This list is in no way intended to serve as the definitive Ministry validation criteria, but is rather intended to provide some guidance to both proponents and Ministry project evaluators until a more comprehensive list of requirements can be developed.)

Validation criteria **may** include some of the following:

- A demonstration that agents found to be mutagenic in a short-term test also cause the endpoint of concern (e.g. cancer, genetic disease, reproductive effects). If no correlation is found, evidence accounting for the discrepancy should be provided.
- A correlation should be made between the potency of mutagenic agents in short-term genotoxicity testing and their potency in longer term *in vivo* testing (e.g. rodent teratogenicity testing).
- Definition of the correlation between an agent's suspected mode of action (e.g. cancer initiator or promoter) and its demonstrated activity in genotoxicity testing.
- Demonstration of dose-dependency and time-dependency for results in a given genotoxicity test.
- An evaluation of the degree of selectivity of the test protocol for the agent(s) tested. A listing of factors (e.g. presence of other toxic agents, disease state) that may influence the outcome of the test.
- A demonstration that the genotoxic potential (as measured by the Ames Test) in an environmental matrix can be expressed as *in vivo* genetic damage (e.g. cellular mutation, chromosomal damage, heritable mutation) in an environmental organism *in situ*.
- A demonstration that *in vivo* genetic damage measured in an environmental organism is correlated with an increased incidence in genetically-related disease (e.g. cancer, heritable mutation, reduced longevity, reduced reproductive success) in that environmental organism.
- A correlation should be made between the genotoxic potency of an environmental matrix and the risk of *in vivo* genetic damage or risk of genetically-related disease in an environmental organism *in situ*.
- An estimation of the background or natural incidence of *in vivo* genetic damage or genetically-related disease in the environmental test organism.
- An evaluation of the degree of selectivity of the measure of genetic damage in an environmental test organism for the presence of genotoxic pollutants in an environmental matrix.

The specificity of genotoxicity test systems requires that a specific set of validation criteria be developed for each potential application of genotoxicity testing.

(G) PEST CONTROL

The Ministry of the Environment recognizes the need to prevent pests from causing economic damage in food and fibre production, in structures, and in food handling establishments. The Ministry is concerned that excessive use of chemical pesticides is contaminating the environment and it wishes to replace the use of environmentally damaging pesticides with methods of pest control that avoid such damage. It is also deeply concerned with pesticide applications done primarily for cosmetic purposes.

In keeping with this philosophy, the Ministry wishes to pursue research that provides a better understanding of the nature and extent to which pesticides or their degradation products contaminate the environment (air, aquatic, terrestrial) so that they can be regulated in such a way that damage is negligible. It wishes also, to explore integrated pest management approaches that maximize the effectiveness of biological and cultural methods of pest control and reduce pesticide use.

The Ministry places a high priority on research into the impact of pesticides on aquatic and terrestrial ecosystems, and the extent and significance of pesticide contaminants in natural and drinking waters.

The Ministry has adopted the following goals:

1. To support the Ontario Ministry of Agriculture & Food's Food Systems 2002 program which aims to reduce the use of chemical pesticides by 50% by the year 2002. This can be done by replacing single strategy pest control methods with integrated pest management strategies.

2. To eliminate the use of pesticides that cause damage to the environment through contamination of water, air or soil and/or impact on wildlife and retain only those that are environmentally benign. The Ministry will develop criteria for defining "environmentally benign".

3. To develop practices for urban lawn and garden maintenance that reduce or eliminate reliance on pesticides.

4. To develop integrated pest management practices in structural pest control so that the use of pesticides in and around structures is reduced.

5. To eliminate pesticide spills, since these cause major environmental and health impacts.

6. To ensure that the pesticide industry develops and implements methods of pesticide container disposal (reuse, recycle, etc.) that are safe to the environment. The Ministry will monitor disposal procedures to verify this goal.

The following issues (G-1 to G-3) support the Ontario Ministry of Agriculture and Food's Food System 2002 program which aims to reduce the use of chemical pesticides by 50% by the year 2002.

This can be done by replacing single strategy pest control methods with integrated pest management strategies.

Issue G-1: ***To Integrate Biological and Cultural Alternatives with Conventional Pest Control Techniques.***

Topics:

G-1.1 To determine through research whether alternative control agents can be integrated into existing conventional approaches to improve the performance of the system.

G-1.2 To determine the compatibilities of chemical and biological control agents.

G-1.3 To investigate why producers are reluctant to adopt integrated pest management strategies.

G-1.4 To develop threshold population values for control actions.

G-1.5 To develop improved methods to monitor pest populations.

Issue G-2: ***To Manage Pest Resistance.***

Topics:

G-2.1 To develop methods to determine initial stages of the development of resistance to pesticides.

G-2.2 To develop methods to detect the initial stages of breakdown of host tolerance (resistance) to pests.

G-2.3 To examine the effect of alternating control strategies on the development of pest resistance.

G-2.4 To investigate combinations of chemical, biological and cultural practices to determine whether the development of resistance can be managed more efficiently using these various approaches rather than rotating chemical agents only.

G-2.5 To examine the mechanisms for cross-resistance to widely different groups of pesticides.

Issue G-3: *To Develop Biological and Other Nonchemical Pest Control Techniques to Synthetic Pesticides for Insect, Weed, Disease and Rodent Control.*

Topics:

G-3.1 To discover natural biological control organisms present in the Ontario environment that could be successfully used to replace chemical techniques.

G-3.2 To investigate exotic biological control organisms that could be introduced into the Ontario environment to replace synthetic pesticides.

G-3.3 To evaluate biochemicals as replacements for petro-chemicals in the control of disease, insect, weed and rodent pests.

G-3.4 To develop pest resistant crop varieties.

Issue G-4 has been identified to eliminate the use of pesticides that cause damage to the environment through contamination of water, air or soil and/or impact on wildlife and retain only those that are environmentally benign. The Ministry will develop criteria for defining "environmentally benign".

The Ministry will, over the next five years, focus on the ten pesticides most used in Ontario (currently, metolachlor, atrazine, 1,3-dicloropropene, 2,4-D, EBDC, metribuzin, EPTC, cyanazine, MCPA, glyphosate), plus a group of other pesticides of special interest (eg. diazinon, tributyltin oxide, carbaryl, chlorpyrifos, terbufos, endosulfan, organometallics). This research will form the basis for making informed decisions on how these pesticides should be regulated.

Issue G-4: *To Examine the Degradation and Fate of Pesticides in Soil, Water, Air and Biological Components of the Environment.*

Topics:

G-4.1 To adapt analytical techniques to follow the metabolic fate of pesticides applied to soils and vegetation be they herbicides, fungicides or insecticides.

G-4.2 To prepare balance sheets on the environmental fate and impact of soil and vegetation applied pesticides, partitioning them into the soil, water, air and biological compartment.

G-4.3 To develop a list of key criteria to evaluate pesticides as to their "environmentally benign" properties and characteristics. eg. persistence, movement, toxicity to non-targets, groundwater contamination.

G-4.4 To adapt methodologies to follow the fate of those pesticides that under normal conditions are gaseous (ie. fumigants) and determine to what extent they move into the atmosphere.

G-4.5 To adapt analytical techniques to follow the metabolic fate of pesticides applied to water or contaminating water.

G-4.6 To study the environmental impact of pesticides on non-target species and to determine recovery.

G-4.7 To determine the fate of pesticides in groundwater.

G-4.8 To adapt analytical techniques to follow the metabolic fate and distribution of pesticides in air.

G-4.9 To determine the aerial transport of pesticides from an application site.

G-4.10 To examine the impact of pesticides on non-target organisms. (eg. earthworms, aquatic organisms, domestic pets.)

G-4.11 To determine the metabolic fate of a pesticide applied under environmentally controlled conditions, i.e. in dry situations with few micro-organisms.

G-4.12 To determine the persistence of organophosphorus insecticides used in homes and apartments to control cockroaches and other pests.

G-4.13 To determine the levels of pesticides in air in homes following pesticide applications.

Issue G-5 has been identified to develop practices for urban lawn and garden maintenance that reduce or eliminate reliance on pesticides.

In this regard, the Ministry will investigate the public attitude toward urban lawn and garden maintenance and determine what cultural practices might meet public aspirations.

Issue G-5: ***To Reduce the Cosmetic Use of Pesticides.***

Topics:

G-5.1 To determine pesticide use practices in urban environments.

G-5.2 To develop criteria for assessing the need for pesticides for aesthetic purposes.

G-5.3 To develop criteria for assessing the public acceptance of pesticides in urban environments.

G-5.4 To investigate the socio-economic aspects of urban cosmetic pest control.

G-5.5 To develop effective monitoring techniques for insects, diseases, and emerged weeds in landscape situations so that preventative pesticide applications for cosmetic purposes can be avoided.

The following issue has been identified to develop integrated pest management practices in structural pest control so that the use of pesticides in and around structures can be reduced.

Issue G-6: ***Many structural pest problems are chronic in character (cockroaches, rodents) and persist due to human practices in spite of repeated pesticide applications. True integrated pest management practices are not the norm in the urban environment.***

Topics:

G-6.1 To determine public attitudes towards pests and pest control practices in structures.

G-6.2 To review and assess pest control practices in structures.

G-6.3 To develop integrated pest management protocols for structures.

Issue G-7 deals with elimination of pesticide spills, since these cause major environmental and health impacts.

Issue G-7: ***To develop methods of preventing pesticide spills and determining the environmental impact of same.***

Topics:

G-7.1 To determine how ecosystem processes are affected when the normal biological systems are overcome by high concentrations of pesticide as occurs under spill conditions.

G-7.2 To review actual spills in both terrestrial and aquatic environments and determine their persistence and impact. Develop case histories and means of preventing spills by studying these case histories.

G-7.3 To assess the effectiveness of procedures for cleaning up spills and detoxification of soils and waters.

G-7.4 To determine residence times in aquifers that become contaminated.

(H) 3Rs

Issue H-1: *Composting*

Topics:

H-1.1 What facility design features and operating parameters are needed for a facility to be acceptable to the community in which it is sited?

H-1.2 How is the stability of finished compost determined in Ontario (finished compost standards)?

H-1.3 How will the compostable material be collected?

Issue H-2: *Other Organic Waste Processing Technology /Animal Feed and Rendering Technology*

Topic:

H-2.1 Assess the advantages and disadvantages of the technologies.

Issue H-3: *Paper/Fibre*

Topics:

H-3.1 Assess paper / fibre recycling technology.

H-3.2 Determine appropriate source separation and collection strategies and methods.

H-3.3 Develop markets and marketing strategies.

Issue H-4: *Overall Infrastructure/System Design for Dry Recyclables (including Household Hazardous Waste)*

Topics:

H-4.1 Determine appropriate source separation and collection strategies and methods.

H-4.2 Assess the recycling technologies.

H-4.3 Develop markets and marketing strategies.

Issue H-5: *Reuse Opportunities*

Topics:

H-5.1 What quantities and types of reusable materials are available in the wastestream?

H-5.2 Which organizations are currently involved in reuse activities and how can the number of organizations involved be increased?

H-5.3 What are the quantities and types of items being reused currently? How can we increase the quantity and types of items being reused?

Issue H-6: *Flow Control, Pricing, Cost-Related Issues*

Topics:

H-6.1 Determine the possible waste management system component ownership and operator scenarios.

H-6.2 Assess the advantages and disadvantages of the possible combinations.

Issue H-7: *Taxes/Subsidies and Benefits/Costs Related to the Growth of the Secondary Materials Market*

Topics:

H-7.1 Determine the projected economic benefits to Ontario from the development of secondary materials industries.

H-7.2 Where, how quickly, and in what form are these benefits/costs most likely to be felt?

Issue H-8: *Social Behaviour*

Topics:

H-8.1 What level of awareness, of acceptance, of participation by the public can be anticipated?

H-8.2 How much individual initiative can be expected?

H-8.3 What programs and strategies need to be developed and implemented to further extend the personal involvement of Ontario's citizens?

Issue H-9: ***Environmental Contaminants (i.e. Metals)***

Topics:

H-9.1 Assess the risk associated with industrial organic contaminants related to incidence, impact, fate, translocation etc..

H-9.2 What standards are required and how can standards be responsibly developed so as to maximize the opportunity for reduction, reuse and recycling of current wastestream materials (ie. sewage sludge)?

H-9.3 Explore potential opportunities for using waste materials (ie. other sludges) for productive purposes (eg. land application/amendment).

Issue H-10: ***Landfill Capacity Assessment***

Topics:

H-10.1 What is the density of the major wastestreams, and in particular the density of wastestreams from major waste generators?

H-10.2 What densities can be achieved during the collection of different waste and recyclable streams (eg. MSW, Blue Box, ICI source separated)?

H-10.3 What densities are achievable in the landfill?

Issue H-11: ***Tires***

Topic:

H-11.1 Research value added product development from scrap tire material including: rubber and plastic composites; and, 100% rubber.

Issue H-12: *Collection Technology for wastestreams not covered in Issue No. H-4.*

Topics:

H-12.1 Assess the effectiveness of current methods, including consideration of the container.

H-12.2 Recommend alternative methods.

H-12.3 Assess the worker health and safety aspects.

Issue H-13: *Plastics*

Topics:

H-13.1 In product design, can the use of composite manufacturing techniques be minimized (use fewer resins)?

H-13.2 Research collection and separation strategies and technologies.

H-13.3 Develop reusable plastic containers for food and beverages.

Issue H-14: *Packaging/Market Research*

Topics:

H-14.1 Address packaging issues arising out of the National Packaging Protocol process.

H-14.2 Research strategies and technologies to minimize the amount of packaging used.

H-14.3 Address point of purchase (POP) issues that relate to the purpose for the packaging and the effect of the packaging on the consumer.

(I) WASTE MANAGEMENT - LIQUID & SOLID

Issue I-1: ***Groundwater Contamination from Landfills***

Topics:

I-1.1 What is the critical contaminant in landfill leachate?

I-1.2 Can we improve current methods for predicting contaminant plume development?

I-1.3 Are there appropriate remediation methods for landfills?

Issue I-2: ***Methods, Materials and Performance of Landfill Liners***

Topics:

I-2.1 What are the service lives of various types of landfill liners?

I-2.2 How much leakage is there through various types of landfill liners?

I-2.3 How can the performance of landfill liners be monitored?

Issue I-3: ***Methods, Materials and Performance of Landfill Covers***

Topics:

I-3.1 How much water will infiltrate through various types of landfill covers?

I-3.2 What are the maintenance requirements for various types of landfill covers?

I-3.3 What are the benefits of various types of landfill covers?

Issue I-4: ***Production, Control, Collection and Use of Landfill Gas***

Topics:

I-4.1 How much and what kinds of gases migrate through landfill covers?

I-4.2 Does the type of cover or the type of venting influence flux of gas through the cover?

I-4.3 Are the gases that migrate through landfill covers a significant environmental concern?

Issue I-5: ***Methods, Materials and Performance of Leachate Collection Systems***

Topics:

I-5.1 What are the service lives of various types of leachate collection systems?

I-5.2 What are the efficiencies of various types of leachate collection systems?

I-5.3 What are appropriate designs for leachate collection systems in Ontario?

Issue I-6: ***Site Remediation***

Topics:

I-6.1 What parameters and levels of contaminants indicate remediation?

I-6.2 What parameters affect bioremediation?

I-6.3 Disadvantages/Advantages of in-situ vs above ground treatment?

Issue I-7: ***Hazardous Waste Minimization***

Topics:

I-7.1 Which chemicals are most amenable to reduction, reuse and recycling?

I-7.2 What are environmental risks of minimization?

I-7.3 How effective in longterm are solidification/stabilization technologies?

Issue I-8: ***Biomedical Waste Treatment***

Topics:

I-8.1 What criteria should be used to assess treatment efficiency?

I-8.2 How infectious are various biomedical wastes?

I-8.3 How effective are non-incineration treatment systems?

(J) WATER MANAGEMENT

Issue J-1: *Watershed Management*

Commitments/Expectations:

- Sustainable Development and Ecosystem philosophies require linkages between land use planning and watershed management.
- Great Lakes Water Quality Agreement requires watershed management planning.
- Program was endorsed by MOE Management Committee in November, 1990.
- Program related to the endorsed Crombie and Kanter reports that deal with land/water use.
- Program related to the Sewell Commission on Planning and Development Reform.

More than 100 municipalities are currently revising their official plans.

Timing of Milestones:

6 months:

- Development of Provincial Guidance Documents for the development of watershed plans and Sub-watershed Master Plans.
- Water Management Plan input package for municipalities.

1992-93:

- Prioritization of Ontario's watersheds and establishment of a funding program to allow the development of watershed plans.
- Sewell Commission to file its final report that is expected to recommend changes to and integration of various acts.

Environmental Benefits and Costs:

Better land use planning and Protection of water resources that will not only preserve the natural environment for future generations but will also provide substantial cost savings over the long-term by reducing the need for remedial activities i.e., no more RAP areas of concern).

- Long-term maintenance of areas that currently have high water quality.
- Watershed Management will afford substantial protection to ground water resources (surface and ground water management are closely linked).

• Cost savings through Watershed Management initiatives will be needed to offset expenditures in other MOE priority programs.

Decision/Resource Requirements:

- Decisions will be required on using the Planning Act to mandate water resources and other environmental planning responsibilities.
- MOE must commit greater attention to Municipal Plan input.

Anticipated Benefits of Research:

Watershed Management is a comprehensive program to assess and intelligently manage and develop land and water use. One goal is to achieve a sustainable level of water quality that would be acceptable for all appropriate uses.

J-1.1 and J-1.2 will provide scientifically-sound methods for the efficient collection and interpretation of water quality data.

J-1.3 will develop a process for evaluating water quality in "ecoregions" and identify obtainable levels of water quality.

J-1-4 seeks the selection of appropriate biotic indices that could be successfully applied to assess and monitor trends in surface water quality conditions.

Topics:

J-1.1 Development of valid water sampling program design and Q/A protocols for the statistical evaluation of the resulting water quality data for identifying non-compliance of surface waters with the Provincial Water Quality Objectives (MOE, Water Management, 1984)

J-1.2 Development of statistical procedures and water quality models for integration and analysis of province-wide water quality data bases within the context of GIS.

J-1.3 Develop the concept of an ecoregion - surface water quality classification scheme for selected parts of Ontario that could be employed to identify obtainable water quality.

J-1.4 Evaluate available aquatic ecosystem health indicators (e.g. indices of biotic integrity, etc.) for water quality and benthic communities and prepare a set of application procedures for the most promising indicators that could be used in Ontario.

Issue J-2: *Zebra Mussel Control*

Commitments/Expectations:

Interim Certificates of Approval are being issued for the use of chlorine as a stop-gap measure until environmentally-safe methods are developed for the control of zebra mussel growths on water intakes.

Municipalities are expecting Capital grants for retrofitting water intakes for zebra mussel control. 110 intakes may be impacted by this invader.

Environmental Benefits and Costs:

- Innovative techniques will reduce or eliminate the environmentally-hazardous use of chlorine for zebra mussel control on water intake structures.
- Research will permit resource managers to evaluate the negative and positive implications of zebra mussel proliferation on the quality and uses of impacted Ontario waterbodies. Plans can then be made to live with this intruder at minimal environmental costs and consequences.

Decisions/Resource Requirements:

Effective and environmentally-safe actions must be found and quickly implemented to control zebra mussels and minimize the cost of intake protection to the Province, municipalities, utilities, etc.

Anticipated Benefits of Research:

The intrusion of zebra mussels in wide-spread areas of the Great Lakes is of serious concern. The organisms ability to grow in large masses on submerged objects poses a threat to the efficient operation of water intakes. Infestations of large numbers of these organisms also raise questions about their impact on water quality.

J-2.1 seeks solutions to the clogging of drinking water treatment facility intakes by the massive growth of zebra mussel colonies.

J-2.2 will shed light on the impact of zebra mussel infestations on water quality.

Topics:

J-2.1 Development of an environmentally-safe technology to minimize or eliminate the growth of zebra mussel colonies in drinking water intake structures.

J-2.2 Evaluation of the impact of zebra mussel infestations on phosphorus concentrations in the Great Lakes and determination of the effects that zebra mussels and other recently introduced exotic organisms might have on a) the lakes' trophic structure, and b) the fate of organic and inorganic trace contaminants in aquatic ecosystems.

Issue J-3: *Municipal-Industrial Strategy for Abatement (MISA)*

Anticipated Benefits of Research:

The research needs identified for this issue relate to environmental protection through the application of innovative technology and procedures at municipal and industrial waste treatment facilities.

Specifically, J-3.1 and J-3.2 call for the development of procedures and mechanisms for the overall operation and management of facilities. J-3.3 through J-3.7 identify the need for the development of procedures that would improve the ability to remove toxics. J-3.8 seeks innovative, pollution prevention alternatives to waste treatment.

Topics:

J-3.1 The development and refinement of on-line, real-time sensors for a wide range of physical (eg. flow, level, pressure, etc.) and chemical (eg. phosphorus, ammonia, oxidants, TOC, organics, etc.) parameters for measurement of conditions at wastewater treatment facilities. Characteristics of the sensors would include - accuracy, reliability, durability, stability, low life-cycle costs, automated calibration, sensor self-diagnosis and compatibility with distributed control systems.

J-3.2 Development and implementation of integrated computer systems for use in sewage treatment utilities that would include components for process monitoring and control, maintenance, laboratory and field data, geographic information, emergency services and business systems.

J-3.3 Assessment and/or development of specific treatment technologies that would upgrade or add modules to conventional sewage treatment plants to facilitate the effective removal/treatment of synthetic toxic substances and metals.

J-3.4 The evaluation of ultraviolet light and oxidants (such as H202) to reduce contaminant loadings in selected organic waste streams.

J-3.5 Evaluation of the applicability of electrolysis for metal removal from wastewater streams.

J-3.6 Development and demonstration of technologies that will prevent acid mine drainage from occurring in waste rock piles and at tailings sites.

J-3.7 Development of advanced oxidation processes for the destruction of dioxins in the effluent streams coming from the platforming process in oil refineries. A pilot-scale performance feasibility study using at least three different dioxin concentrations is recommended.

J-3.8 The development and evaluation of pollution prevention alternatives such as - waste reduction through best management practices and raw material, process and/or production changes (e.g. the replacement of chlorine with oxygen for delignification in pulp bleaching); recycling/reuse; and treatment for commercial and industrial activities.

Issue J-4: *Drinking Water Protection Program*

Anticipated Benefits of Research:

The research needs identified for this issue relate to the provision of high quality drinking water through the application of innovative technology and procedures at drinking water treatment plants.

Specifically, J-4.1 through J-4.4 call for the development of procedures and mechanisms for the overall operation and management of water treatment facilities. J-4.5 through J-4.8 identify the need for specific research and technology development to treat specific contaminants, treatment by-products or emerging problems related to the provision of high quality drinking water.

Topics:

J-4.1 Development of computer-based treatment process choice mechanism for use as a decision-making framework for the removal or reduction of trace contaminants from drinking water. The system would be based on the (chemical and physical characteristic of the contaminant and the response of similar contaminants to treatment.

J-4.2 The development and refinement of on-line, real-tine sensors for wide range of physical (e.g. flow, level, pressure, etc.) and chemical (eg. phosphorus, ammonia, oxidants, TOC, organics, etc.) parameters for measurement of conditions at sewage treatment facilities. Characteristics of the sensors would include - accuracy, reliability, durability, stability, low life-cycle costs, automatic calibration, sensor self-diagnosis and compatibility with distributed control systems.

J-4.3 Development and implementation of integrated computer systems for use in sewage treatment utilities that would include components for process monitoring and control, maintenance, laboratory and field data, geographic information, emergency services and business systems.

J-4.4 Development of models/algorithms for water treatment process removal of contaminants, especially toxins.

J-4.5 Development of treatment processes for by-product control in drinking water treatment with emphasis on small systems and highly-coloured water.

J-4.6 Development of treatment processes for particulate removal in drinking water treatment.

J-4.7 Identification of compounds responsible for taste and odour problems in drinking water and the development of treatment processes to address these problems.

J-4.8 Development of a technology to minimize or eliminate the growth of zebra mussel colonies in drinking water intake structures.

Issue J-5: ***Groundwater Protection Program***

Anticipated Benefits of Research:

Groundwater is the source of water supply for many municipalities, farms, industry and individuals. It is also the source of many of Ontario's river basin systems.
Groundwater is susceptible to contamination from many human activities and very slow to recover from misuse. Resource managers must be aware of groundwater conditions and potential impacts so that the quality and knowledgable use of the resource can be sustained.

Program J-5.1 calls for research to assess tools that will lead to understanding of the implications of contaminants on groundwater. J-5.2 and J-5.3 identify research and technology development required to protect groundwater from specific activities.

Topics:

J-5.1 Assess merit of available models designed to evaluate the implications of contaminants (i.e., sources, pathways, fate, etc.) on the quality, uses and protection of groundwater.

J-5.2 Development of alternative and/or innovative private sewage/septic treatment systems that are environmentally safe (i.e. do not have the potential to impair surface or groundwater quality).

J-5.3 Determination and evaluation of the impact of heat pump loop systems on groundwater and surface runoff.

Issue J-6: *Remedial Action Plans*

Anticipated Benefits of Research:

In many Great Lakes Areas of Concern, Remedial Action Plans must address the implications of sediments contaminated with metals and hazardous organic substances on water quality and use. Issues such as contaminant cycling, availability, impacts on aquatic communities and remedial measures are being addressed and must be supported by appropriate research.

Program J-6.1 relates to the need to understand contaminant cycling, transformation and bioavailability for developing effective management plans. J-6.2 and J-6.3 lead to the application of reliable testing procedures and an understanding of the toxicological impacts of contaminants on aquatic biota. J-6.4 will provide a means for the in-place management of contaminated sediments.

Topics:

J-6.1 Measurement of the uptake and release of trace organic and inorganic substances from sediments; assessment of the transformations of such substances in sediments; and determination of the availability of these organic and inorganic substances directly frcm sediments or from suspended sediments to aquatic organisms.

J-6.2 Development of simple, reliable, laboratory-based techniques to evaluate the potential impacts of contaminants in sediment (in-place pollutants) on the aquatic ecosystem.

J-6.3 Determination of the effects (metabolic, behavioural, reproductive, etc.) of chronic exposure of aquatic organisms to trace organic contaminants such as PCBs, PAHs, chlorinated dioxins and dibenzofurans.

J-6.4 Development of techniques for the in situ treatment/immobilization of contaminants in sediments (e.g. chemical fixation, overlaying with clean material, etc.).

Issue J-7: *Risk Assessment*

Anticipated Benefits of Research:

Provincial Water Quality Objectives (PWQO) are fundamental tools in managing surface water quality in Ontario. The Objectives are designed to provide life-long protection to the varieties of aquatic organisms found in this Province's rivers and lakes. To set an objective, an array of chronic effect toxicological studies are needed for a representative cross-section of aquatic species. This type of information is not always available.

Program J-7.1 will provide the specific chronic toxicity information for a defined list of chemicals that are candidates for PWQO setting.

Topics:

J-7.1 Develop information on chronic toxicity of specified chemicals to fish and aquatic invertebrates that will permit the promotion of Provincial Water Quality Guidelines (PWQG) to Provincial Water Quality Objectives. The specific chemicals and species are identified in the 'Research Needs' chapters of PWQG documents available from MOE.

For the MOE policy on funding of Genotoxicity research, please see page 32.

Issue J-8: ***Maintenance of Expertise***

Topics:

J-8.1 The development of empirical models to describe the partitioning of mercury and methyl mercury in watershed soils, streams and oligotrophic, softwater lakes.

Benefits: Sport fish consumption restrictions, where they apply in Ontario's inland lakes, are related almost exclusively to the presence of elevated levels of mercury in fish tissue. This research will assist in identifying possible management strategies to reduce mercury in fish.

J-8.2 Evaluation of the effects of persistent, bioaccumulative organic compounds and metals on the community structure and health of aquatic organisms at various levels in the food chain.

Benefits: The information gained from this research will be essential in the development of guidelines for the protection of aquatic life and form an important component of the Provincial Water Quality Objective (PWQO) setting process.

J-8.3 Determination of the toxicity to aquatic life of the speciated forms of metals that are discharged to or occur naturally in surface waters and identification of the factors (physical, chemical, etc.) that increase or modify the toxicity of metals.

Benefits: Traditionally, PWQOs and water quality sampling have been related to total metal (e.g. total copper) concentrations. Information obtained from this research will permit a re-evaluation of this approach and direct management actions to specific toxic forms and influencing factors.

J-8.4 Assess the impacts of pulse exposures of contaminants on aquatic biota (e.g. impacts of periodic storm water or industrial effluent discharges, etc.).

Benefits: Concentrations of contaminating substances in discharge or watercourses are not always constant. This research will identify the impact of fluctuating pollutant concentrations on the health of aquatic life.

J-8.5 Evaluation of the effects of solid particles in cyanide samples as they relate to the collection, preservation and analysis of water supplies.

Benefits: Findings from this research should result in more reliable methods for obtaining accurate cyanide concentrations in water samples.